- Page 4, lines 5-10
- Page 5, lines 2-7
- Page 5, line 20 to Page 6, line 1
- Page 6, lines 2-4
- Page 6, lines 5-12
- Page 6, lines 17-20
- Page 7, lines 11-17
- Page 8, lines 3-7
- Page 8, lines 13-20
- Page 11, lines 13-15
- Page 11, lines 20-25

IN THE ABSTRACT:

Please amend the abstract as indicated by the clean copy of the amended abstract in Appendix E, and the marked-up copy of the amended abstract in Appendix F, attached hereto.

REMARKS

Reconsideration of the application is respectfully requested for the following reasons:

1. Rejection of Claims 4-6 Under 35 USC §112, 1st Paragraph

a. Phase Velocity

This rejection is respectfully traversed on the grounds that the description of the invention, and in particular the explanation of equation 2 on page 4 of the specification, makes sense only if "velocity" is interpreted as "phase velocity." Those skilled in the art would have recognized, for example, that equation 2 is the well-known equation for the effect of capacitances on *phase* velocity and not propagation speed, as alleged by the examiner.

The term "velocity" is by itself meaningless in the context of a traveling wave. In order to measure the "velocity" of a wave, some reference must be chosen, such as the peak of a wave. The rate at which peak moves is known as the "phase velocity." That phase velocity is a standard measure of a traveling wave is evident from the definition of the "phase velocity" of a traveling

wave at a single frequency in the *IEEE Standard Dictionary of Electrical and Electronics Terms*, 1984:

The velocity of an equiphase surface along the wave normal.

Those skilled in the art would therefore immediately have understood that Equation 2 on page 4 of the specification is clearly the equation for phase velocity of the input and output signals, and therefore all of the other references to "velocity" included in the original specification must be references to phase velocity. Indeed, the entire specification makes no sense if velocity does not mean "phase velocity."

Although the word "phase" was lost in the translation of the present application from Korean, it is respectfully submitted that the term "velocity" would nevertheless have been clearly understood as the –phase velocity–. To correct the translation "error," Applicant proposes to amend the specification to consistently refer to phase velocity, but notes that the word "phase" is in any case implicit in the term "velocity" as applied to a "traveling wave."

b. Gain Ripple

It is respectfully submitted that the phrases "reduced gain ripple" and "increased gain flatness" are equivalent, and that the recitation of "reduced gain ripple" is therefore supported by the description of "improved bandwidth, **gain flatness**, and stability compared to traveling-wave amplifiers having the conventional output transmission" in lines 8-20 on page 8 of the specification. As those skilled in the art would immediately appreciate, the less ripple, the flatter the gain.

1. Claim Objection

This objection has been addressed by amending claim 4 to recite that the bandwidth is –maximized– relative to unmatched designs, as suggested in lines 7-11 on page 4 of the Official Action ("*While it can be said that the bandwidth is increased over the unmatched design of the*

prior art, the bandwidth is not increased over any existing theoretical maximum width, only that it is maximized").

3. Rejection of Claims 4-6 Under 35 USC §102(b) in view of U.S. Patent No. 5,046,155 (Beyer)

This rejection is respectfully traversed on the grounds that the Beyer patent fails to disclose or suggest the use of additional input and output transmission line capacitances to achieve phase velocity matching, as claimed.

A. Claim 4

According to the Examiner, phase velocity matching is achieved by the passive T-section shown in Fig. 8 of Beyer. In reply, the Applicant respectfully submits that the T-section of Beyer is used for an entirely different purpose and does not provide phase velocity matching. Instead, the T-section provides an extra phase shift in order to move the minimization bandwidth to lower frequencies by the amount shown in col. 4, lines 62-65. It is respectfully submitted that including an extra phase shift has nothing to do with phase *velocity* matching, and that the T-section of Beyer in fact does not achieve, and is not intended to achieve, such matching. To the contrary, the T-section of Beyer actually lowers the bandwidth of the amplifier.

This can be seen from a comparison of Figs. 11 and 12 of Beyer. Fig. 11 shows the effect of a binomially scaled distributed amplifier without a T-section, and Fig. 12 shows that effect of a binomially scaled distributed amplifier with one T-section inserted. S41 in both figures represents the gain of the amplifier. The Examiner will note that the 3-dB bandwidth of the binomially scaled distributed amplifier with one T-section inserted (~8.5 GHz) has been *decreased* compared with the that of the binomially scaled distributed amplifier without a T-section (~10 Ghz). Furthermore, the minimization bandwidth, *i.e.*, the region where S31 is minimum, is shifted to lower frequencies by the use of the T-section. Therefore, it is clear that the role of the T-section of Beyer is solely to move the minimization bandwidth, as shown in

Figs. 11 and 12 and described in col. 5, lines 15-21, and accordingly the region where directivity has a minimum value, shown in Figs. 9 and 10, to lower frequencies.

It is important to understand that phase shifting is a distinct concept from phase velocity matching. The Beyer patent does include phase velocity matching, but not by means of the T-section phase shifter, with its capacitors. Instead, Beyer uses a prior art m-derived termination, as shown in Figs. 1 and 3, to accomplish phase velocity matching. In particular, Beyer utilizes a section of transmission line 28 having length l_m to accomplish phase velocity matching. The problems with phase velocity matching of this type are described in the introductory portion of the present specification in connection with Figs. 3-11.

As in the prior art shown in Figs. 3 and 4 of the present application, the T-sections of Beyer are not and cannot effectively be used for phase velocity matching. Instead, the major goal of Beyer's amplifier circuit is to improve the directivity D, defined in col. 2, lines 1-6 as the logarithmic ratio of S31 to S41 of the traveling wave amplifier. This improvement is achieved through the use of binomial scaling of transconductance g_m, by means of capacitors C_s and C_p (compare Figs. 2 and 3). Binomial scaling has the effect of broadening the bandwidth, as explained in col. 2, lines 17-22, and shown in Fig. 4, but the bandwidth broadening is the result of the constant gain-bandwidth product of the transistor–*i.e.*, as the gain is decreased by binomial scaling, the bandwidth must be increased by a corresponding amount. The bandwidth broadening therefore does not come from phase velocity matching, as alleged by the examiner.

The T-sections are used by Beyer solely to further improve the directivity of the amplifier by providing an extra phase shift in order to move the minimization bandwidth to lower frequencies by the amount described in col. 4, lines 62-65, to achieve the effects shown in Figs. 9-12. The T-sections are not disclosed as being provided for phase velocity matching, and a careful analysis indicates that they do not provide such matching. Therefore, the Beyer patent fails to disclose or suggest the claimed bandwidth-improving additional capacitances, and withdrawal of the rejection of claims 4 under 35 USC §102(b) is respectfully requested.

B. Claim 5

Claim 5 is believed to be patentable not only because of its dependence from claim 4, but also because the Beyer patent fails to disclose or suggest the T-inserts of Beyer cannot meet the capacitor-location limitations recited in claim 5 if they are to perform their stated function.

Fig. A of Exhibit I, attached hereto, shows the equivalent circuit for a conventional distributed amplifier of the type illustrated in Fig. 7 of Beyer. The total length of the artificial drain transmission line connected between drains of the transistors is Ld.

Fig. B of Exhibit I shows the equivalent circuit for the distributed amplifier shown in Fig. 8 of Beyer, including the passive impedance T-inserts for shifting the minimization bandwidth to lower frequencies. The total length of the artificial drain transmission line connected between drains of the transistors, *i.e.*, between nodes 42, is 2Ld (Ld + Ld) due to the addition of the T-insert having length Ld within the drain transmission line of Fig. A.

Fig. C of Exhibit I shows the equivalent circuit of a distributed amplifier constructed in accordance with the principles of the present invention, redrawn for purposes of comparison with the Beyer circuit. The total length of the artificial drain transmission line connected between drains of the transistors in this circuit is Ld.

It can be seen from Fig. B that the length of the artificial drain transmission lines connected on the left and right sides of the capacitor in the T-insert of Beyer is Ld (½Ld + ½Ld, and a fixed value), while lengths of the artificial drain transmission lines connected on the left and right side of the capacitor C_3 are xLd and (1-x)Ld, respectively, where $0<x<1$. For example, if the length of the one on the left is 0.3Ld, then the length of the transmission line on the right is 0.7d, and so forth. It follows, therefore, that Beyer has a different drain transmission line than that shown in Fig. C, which is the transmission line of the present invention.

As is apparent from Figs. A-C of Exhibit I, the locations of the capacitors in the transmission lines of Beyer do not correspond to those of the claimed invention, and therefore Beyer does not anticipate claim 5. This is not a matter of design choice, but rather a function of the fundamental differences, discussed above, in the manner in which the capacitors are used in the circuits of Beyer and the claimed invention, Beyer using the capacitors for phase matching, and the claimed invention arranging the capacitors as the claimed distances for the purpose of phase *velocity* matching.

C. Claim 6

The rejection of claim 6 is traversed for essentially the same reasons as the rejection of claim 5.

As explained above, the total length of the artificial line connected between drains of the transistors shown in Fig. 8 of Beyer is 2Ld, and the length of the artificial transmission lines between the drain of the transistor and the capacitor located in the middle of the T-section is Ld. In contrast, the total length of the artificial transmission line of the present invention is Ld and the length of the artificial transmission lines between the drain of the transistor and the additional capacitor C_3 is 0.5Ld (x=0.5). The length of the artificial transmission line of the present invention is actually more similar to that of the distributed amplifier without T-section shown in Fig. 7 of Beyer, which clearly does not correspond to the claimed invention because it lacks any sort of capacitor located in the middle of the half sections, at Ld/2.

4. Entry of the Amendments

As explained above, the amendments to the specification simply correct an obvious translation error (by changing velocity to phase velocity) that would have been immediately understood by the ordinary artisan, while the amendments to claim 4 correct errors under 35 USC §112 without changing the scope of the claims.

Entry of the amendments is therefore respectfully requested on the grounds that the amendments do not raise new issues, and on the grounds that they materially reduce the issues for appeal.

Having thus overcome each of the rejections made in the Official Action, passage of the application to issue is requested.

Respectfully submitted,

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APPENDIX A
(Clean Copy Of Amended Claims)

4. (Amended) A traveling-wave amplifier, comprising:

an output transmission line including first, second, third, and fourth drain lines;

an input transmission line including first, and second gate lines;

a first FET having a drain terminal connected between said first and second drain lines and a gate terminal connected to said first gate line;

a second FET having a drain terminal connected between said third and fourth drain lines and a gate terminal connected between said first and second gate lines;

a first additional capacitance connected between said second and third drain lines; and

a second additional capacitance connected to the fourth drain line,

wherein said first and second capacitances are arranged to match phase velocities of signals in said input transmission line with phase velocities of signals in said output transmission line and thereby improve gain characteristics by improving gain flatness and maximizing bandwidth of the amplifier relative to an amplifier in which phase velocities are unmatched.

APPENDIX B
(Marked-Up Copy Of Amended Claims)

4. (Amended) A traveling-wave amplifier, comprising:

an [input] output transmission line including first, second, third, and fourth drain lines;

an [output] input transmission line including first, and second gate lines;

a first FET having a drain terminal connected between said first and second drain lines and a gate terminal connected to said first gate line;

a second FET having a drain terminal connected between said third and fourth drain lines and a gate terminal connected between said first and second gate lines;

a first additional capacitance connected between said second and third drain lines; and

a second additional capacitance connected to the fourth drain line,

wherein said first and second capacitances are arranged to match phase velocities of signals in said input transmission line with phase velocities of signals in said output transmission line and thereby improve gain characteristics by [reducing gain ripple and increasing bandwidth] improving gain flatness and [increasing] maximizing bandwidth of the amplifier relative to an amplifier in which phase velocities are unmatched.

APPENDIX C
(Clean Copy Of Amended Paragraphs)

Page 3, line 21 to Page 4, line 1:

B2

Also, the phase velocity of traveling-waves in the input(gate)/output(drain) transmission lines in this structure can be represented by the following equations.

Page 4, lines 5-10:

B3

To optimize the performance of traveling-wave amplifiers, input/output impedance should be matched to 50Ω and the phase velocity of traveling-waves in the input/output transmission lines should be matched. However, the above two matching conditions cannot be satisfied simultaneously for the structure of the traveling-wave amplifier shown in Fig. 1.

Page 5, lines 2-7:

B4

With this condition, the phase velocity of traveling-wave signal (V_{out}) in the output(drain) transmission line is larger compared to the velocity of traveling-wave signal (V_{in}) in the input(gate) transmission line. This indicates that impedance and phase velocity matching conditions cannot be achieved and improvement in gain-bandwidth product of the simple traveling-wave amplifier structure shown in Fig. 1 is limited.

Page 5, line 20 to Page 6, line 1:

B5

In the said T-type drain line structure, to match the phase velocity of traveling-wave in the output line with the phase velocity of traveling–wave in the input line (i.e., to decrease the velocity of the traveling-wave in the output line), Cout is increased by connecting an additional capacitance(C2) to the output of the unit transistor. Equivalently, for the m-derived-line structure, an additional inductor is inserted in series between the drain of the transistor and the drain lines.

Page 6, lines 2-4:

By increasing the output capacitance to Cout=Cd + C2 the Vout value can be decreased to the value close to Vin achieving the phase velocity matching of traveling-waves in the input/output transmission lines.

B6

Page 6, lines 5-12:

Fig. 5 shows the gain-frequency characteristics of 4-stage traveling-wave amplifiers with various drain line structures assuming that the value of the feedback capacitance Cgd of the unit transistor is 0 pF. As can be seen in the figure, bandwidth of the traveling-wave amplifiers having m-derived-type and T-type drain line structures are improved compared with the simple drain line structure (without any additional elements). The improvement is due to the phase velocity matching of traveling-waves in input/output transmission lines.

B7

Page 6, lines 17-20:

As the additional element values in the conventional drain line structures are increased to the values required for phase velocity matching, the stability of the amplifiers is degraded due to the presence of the feedback capacitance Cgd.

B8

Page 7, lines 11-17:

Fig. 7 shows the S11 of traveling-wave amplifiers having different drain line structures when the additional element values are close to the required values for phase velocity matching. As shown in FIG. 7, the S11 values of the traveling-wave amplifiers having T-type and m-derived type drain line structures are larger than 0 dB at the high-frequency region. The amplifiers show oscillatory behavior at the frequency where S11 value is larger than 0 dB.

B9

Page 8, lines 3-7:

The presented invention relates to solve the said matter. The purpose of the present invention is overcoming the stability problem in conventional traveling-wave amplifiers due to

B10

the additional elements used for phase velocity matching associated with the feedback capacitance of unit transistors.

Page 8, lines 13-20

In the π-type transmission line structure, since the additional capacitance is effectively isolate from the output of the unit transistor by the drain transmission line, the effect of the additional capacitance on amplifier's stability problem is reduced. Thus the traveling-wave amplifier having a π-type transmission line structure can maximize bandwidth, and improve gain flatness, and stability, compared to traveling-wave amplifiers having the conventional output transmission line structures.

Page 11, lines 13-15:

Therefore, the additional capacitance (C_3) value that is required to match the phase velocity of input/output traveling-waves perfectly can be used without stability problem.

Page 11, lines 20-25:

In conclusion, the traveling-wave amplifier having π-type output transmission line structure according to the present invention can achieve the improved bandwidth characteristics without degradation of stability of amplifier by separating the additional capacitance used for matching the phase velocities of traveling waves in the input/output transmission line from the output of the unit transistor.

APPENDIX D
(Marked-Up Copy Of Amended Paragraphs)

Page 3, line 21 to Page 4, line 1:

Also, the phase velocity of traveling-waves in the input(gate)/output(drain) transmission lines in this structure can be represented by the following equations.

Page 4, lines 5-10:

To optimize the performance of traveling-wave amplifiers, input/output impedance should be matched to 50Ω and the phase velocity of traveling-waves in the input/output transmission lines should be matched. However, the above two matching conditions cannot be satisfied simultaneously for the structure of the traveling-wave amplifier shown in Fig. 1.

Page 5, lines 2-7:

With this condition, the phase velocity of traveling-wave signal (V_{out}) in the output(drain) transmission line is larger compared to the velocity of traveling-wave signal (V_{in}) in the input(gate) transmission line. This indicates that impedance and phase velocity matching conditions cannot be achieved and improvement in gain-bandwidth product of the simple traveling-wave amplifier structure shown in Fig. 1 is limited.

Page 5, line 20 to Page 6, line 1:

In the said T-type drain line structure, to match the phase velocity of traveling-wave in the output line with the phase velocity of traveling–wave in the input line (i.e., to decrease the velocity of the traveling-wave in the output line), Cout is increased by connecting an additional capacitance(C2) to the output of the unit transistor. Equivalently, for the m-derived-line structure, an additional inductor is inserted in series between the drain of the transistor and the drain lines.

Page 6, lines 2-4:

By increasing the output capacitance to Cout=Cd + C2 the Vout value can be decreased to the value close to Vin achieving the phase velocity matching of traveling-waves in the input/output transmission lines.

Page 6, lines 5-12:

Fig. 5 shows the gain-frequency characteristics of 4-stage traveling-wave amplifiers with various drain line structures assuming that the value of the feedback capacitance Cgd of the unit transistor is 0 pF. As can be seen in the figure, bandwidth of the traveling-wave amplifiers having m-derived-type and T-type drain line structures are improved compared with the simple drain line structure (without any additional elements). The improvement is due to the phase velocity matching of traveling-waves in input/output transmission lines.

Page 6, lines 17-20:

As the additional element values in the conventional drain line structures are increased to the values required for phase velocity matching, the stability of the amplifiers is degraded due to the presence of the feedback capacitance Cgd.

Page 7, lines 11-17:

Fig. 7 shows the S11 of traveling-wave amplifiers having different drain line structures when the additional element values are close to the required values for phase velocity matching. As shown in FIG. 7, the S11 values of the traveling-wave amplifiers having T-type and m-derived type drain line structures are larger than 0 dB at the high-frequency region. The amplifiers show oscillatory behavior at the frequency where S11 value is larger than 0 dB.

Page 8, lines 3-7:

The presented invention relates to solve the said matter. The purpose of the present invention is overcoming the stability problem in conventional traveling-wave amplifiers due to

the additional elements used for phase velocity matching associated with the feedback capacitance of unit transistors.

Page 8, lines 13-20

In the π-type transmission line structure, since the additional capacitance is effectively isolate from the output of the unit transistor by the drain transmission line, the effect of the additional capacitance on amplifier's stability problem is reduced. Thus the traveling-wave amplifier having a π-type transmission line structure can [achieve improved] maximize bandwidth, and improve gain flatness, and stability, compared to traveling-wave amplifiers having the conventional output transmission line structures.

Page 11, lines 13-15:

Therefore, the additional capacitance (C_3) value that is required to match the phase velocity of input/output traveling-waves perfectly can be used without stability problem.

Page 11, lines 20-25:

In conclusion, the traveling-wave amplifier having π-type output transmisision line structure according to the present invention can achieve the improved bandwidth characteristics without degradation of stability of amplifier by separating the additional capacitance used for matching the phase velocities of traveling waves in the input/output transmission line from the output of the unit transistor.

APPENDIX E
(Clean Copy of Amended Abstract)

The present invention relates to a traveling-wave amplifier having a Π-type output transmission line structure. In traveling-wave amplifiers having conventional output line structures including T-line and m-derived-line structures, additional capacitance and inductance are attached to the output of the transistors for phase velocity matching in input/output transmission lines in order to improve gain-bandwidth product. However, it is difficult to achieve phase velocity matching of output/input transmission lines without stability problems due to the influence of the additional capacitance and inductance through the feedback capacitance of the transistor used. The present invention provides a traveling-wave amplifier having a Π-type output transmission line structure, where the additional capacitance used for phase velocity matching of the input/output transmission lines is connected in the middle of the output line. Since the additional element is isolated from the output of the transistor by the output transmission line, the Π-type output transmission line structure can achieve phase velocity matching of output/input transmission lines without stability problems associated with the additional capacitance and the feedback capacitance of the transistor. The traveling-wave amplifier having a Π-type output transmission line structure has an improved bandwidth, gain flatness, and stability compared to traveling-wave amplifiers having the conventional output line structures.

APPENDIX F
(Marked-Up Copy Of Amended Abstract)

The present invention relates to a traveling-wave amplifier having a Π-type output transmission line structure. In traveling-wave amplifiers having conventional output line structures including T-line and m-derived-line structures, additional capacitance and inductance are attached to the output of the transistors for <u>phase</u> velocity matching in input/output transmission lines in order to improve gain-bandwidth product. However, it is difficult to achieve <u>phase</u> velocity matching of output/input transmission lines without stability problems due to the influence of the additional capacitance and inductance through the feedback capacitance of the transistor used. The present invention provides a traveling-wave amplifier having a Π-type output transmission line structure, where the additional capacitance used for <u>phase</u> velocity matching of the input/output transmission lines is connected in the middle of the output line. Since the additional element is isolated from the output of the transistor by the output transmission line, the Π-type output transmission line structure can achieve <u>phase</u> velocity matching of output/input transmission lines without stability problems associated with the additional capacitance and the feedback capacitance of the transistor. The traveling-wave amplifier having a Π-type output transmission line structure has an improved bandwidth, gain flatness, and stability compared to traveling-wave amplifiers having the conventional output line structures.

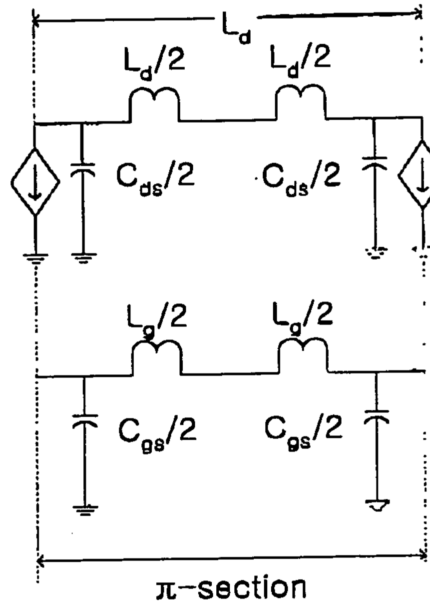

Fig. A. Equivalent circuit of a conventional distributed amplifier (Replica of the π-section of FIG. 7 in Beyer's patent)

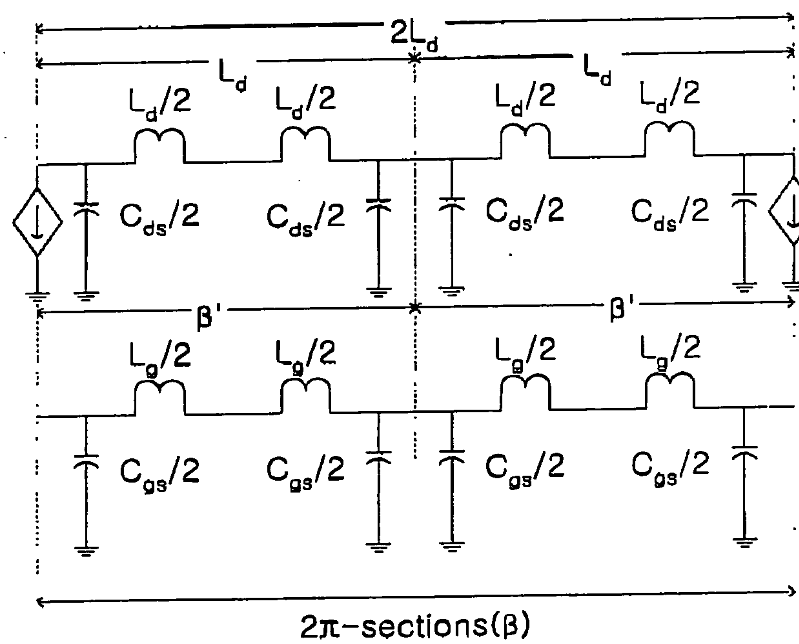

Fig. B. Equivalent circuit of a distributed amplifier in accordance with the Beyer's invention employing passive impedance T-inserts for shifting the minimization bandwidth to lower frequencies (Replica of 2π-section of FIG. 8 in Beyer's patent)

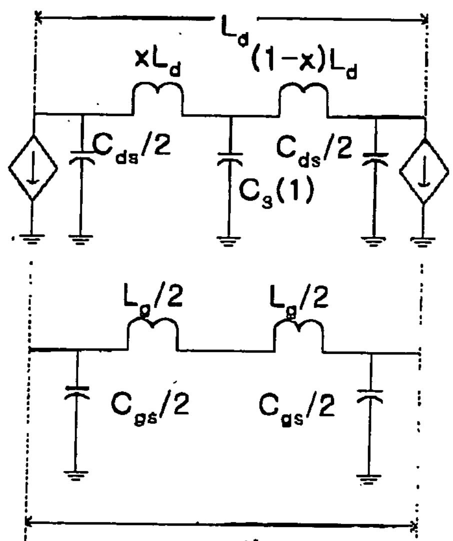

Fig. C. Equivalent circuit of a distributed amplifier in the present invention redrawn for comparison.